AIRCRAFT

ABSTRACT

The United States aircraft industry continues to be a critical element of economic, political, and military power. It is second to none in export dollars and fills a place that cannot be substituted by any other industry. The U.S. aircraft industry was once dominant in the global aircraft market, but Europe has now reached a level of parity in commercial transport sales and is closing the gap in military and rotorcraft sales. The mergers and reorganizations of the industry's four main sectors--commercial transport and cargo, military fixed-wing, rotorcraft, and jet engines--have slowed and companies are adjusting to these new partnerships. Aircraft manufacturers currently focus more on near term profits and stock value, as the concerns of investors and Wall Street positioning overrides research and development and long term investment. The search for greater profitability continues to drive production process streamlining. This streamlining has promoted healthy competition that has stirred innovation in airframes and engines, management practices, design and manufacturing processes, and production tooling. However, there is still uncertainty in both the commercial and military markets. Future market share and profitability for the U.S. industry hangs on the thin threads of government regulations, politics and partnerships. The correct combination of these factors will determine the future of the U.S. aircraft industry.

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2001	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
2001 Industry Studies: Aircraft	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **The Industrial College of the Armed Forces National Defense University Fort McNair Washington, DC 20319-5062**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**22**	

PLACES VISITED

Domestic:
Aerospace Industries Association, Washington, DC
The Boeing Company, Seattle, WA and Washington, DC
Boeing Military Aircraft, St. Louis, MO, Long Beach and Palmdale, CA
Lockheed Martin Aeronautics, Marietta, GA and Washington, DC
Northrop Grumman, Palmdale, CA
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International:
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Rolls-Royce Military Aero Engines, Ltd., Bristol, United Kingdom
Airbus Industrie, Toulouse, France
EADS, Toulouse, France
SNECMA, Villaroche and Corbeil, France

BRIEFINGS

Aviation Week and Space Technology Magazine
Department of Commerce
General Electric Aircraft Engines
Merrill Lynch Aerospace Marketing
Teal Group

INTRODUCTION

The aircraft industry is a major contributor to the U.S. economy and national security. In 2000, total sales by U.S. manufacturers topped $144B.[1] The export portion of sales was $58.9B, making aircraft industry sales one of the few areas where the U.S. has been able to maintain a strong favorable trade balance. (Figure 1). In 1999, the industry provided jobs for nearly 500,000 Americans, half of those in production work.[2] The aircraft industry is also one of our country's leaders in high technology and stimulates innovation in other industries.

This report focuses on four sectors of the aircraft industry: commercial transport (at least 100 passenger capacity) and cargo aircraft, military fixed-wing aircraft, rotorcraft (military and commercial helicopters and tilt rotor aircraft), and aircraft jet engines. Two companies dominate the commercial aircraft business, Boeing and the Airbus Integrated Company (AIC). There are four companies that dominate the military fixed-wing market, Boeing, Lockheed Martin, BAE Systems, and Dassualt. The rotorcraft segment consist of the three major U.S. manufacturers, Bell Helicopter (Textron), Boeing, and Sikorsky Aircraft (United Technology Corporation) and their two principal European competitors, Eurocopter (Germany and France) and AgustaWestland (Italy and Great Britain). The world's aircraft engine market has two major U.S. companies, General Electric (GE) and Pratt & Whitney (P&W), and two major European companies, SNECMA in France, and Rolls-Royce in the United Kingdom, which includes Rolls-Royce Allison in the U.S.

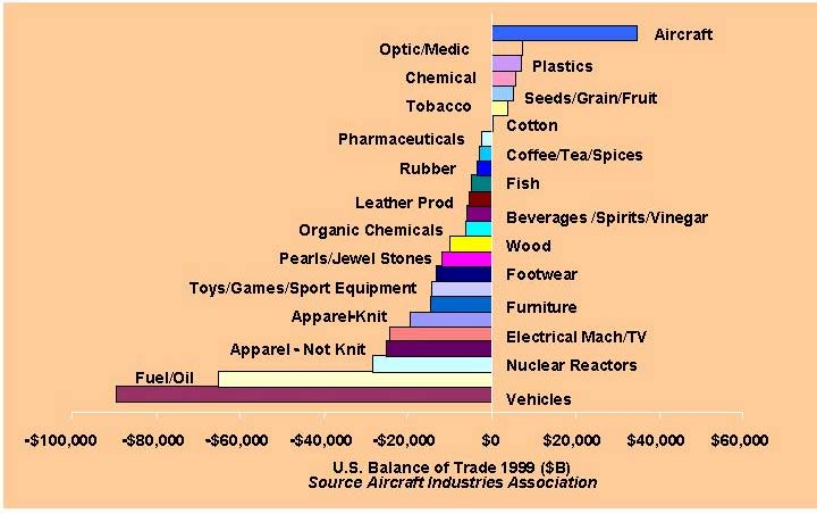

Figure 1

OVERVIEW. The current state of the aircraft industry is one of great promise, but continued uncertainty. There are numerous issues, the outcomes of which will influence the health of the industry in the coming decade. On the commercial side, Airbus announced plans to go forward with a new jumbo jet, the A380. Boeing followed by announcing plans for a new higher speed commercial jet dubbed the "Sonic Cruiser." These new aircraft concepts are the product of different views on how to service the growing air travel market. Since the A380 and the Sonic Cruiser will service separate markets, both approaches can be successful, but each will impact competition for overall market share.

The demand for commercial aircraft, driven by traffic growth and the need to replace older aircraft, will stimulate the commercial aircraft market for the next 10-20 years (Figure 2). However, intense competition is driving profit margins down and forcing companies to find other sources of revenue. There is also an increasing trend towards airline consolidation and commercial aircraft ownership by large aircraft leasing companies, which is reducing the customer base and enhancing their pricing leverage. This consolidation is adding to the intense competition for commercial aircraft and engines, forcing manufacturers to consider reducing prices and offering attractive purchase incentives. To compensate for the extremely small profit margins in today's market both Boeing and Airbus are focusing on service and support opportunities.

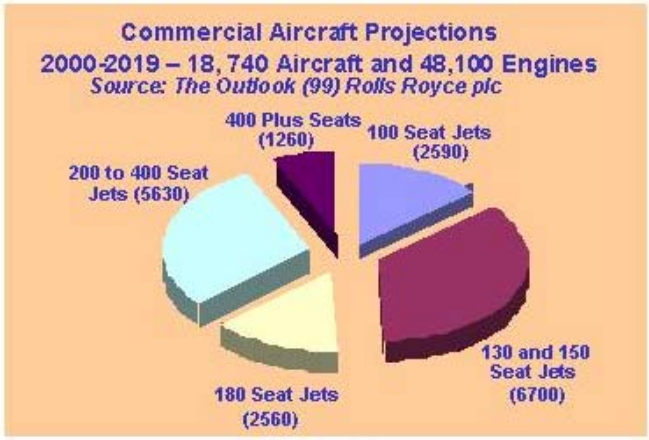

Figure 2

The military aircraft market also faces a great deal of uncertainty. If all military aircraft development and procurement programs currently envisioned (F-22, F/A-18E/F, EuroFighter Typhoon, Rafale, the A400M EuroTransport and Joint Strike Fighter) go forward as planned, the next decade of production for high performance military aircraft will be extraordinary. The approved requirement for the Joint Strike Fighter (JSF) alone is for almost 2000 aircraft for the U.S. services with approximately 1000 more in projected foreign military sales. Additionally, the rotorcraft industry is in a period of transition, marked by uncertain demand. Substantial growth in this market depends on the administration's decision relative to the V-22 tiltrotor. Strengths of the U.S. military sector include the positive influences of multi-year procurements of the FA-18E/F and C-17 and export policies being applied to JSF, which appear to be opening the market. Negative influences include significant overcapacity in both fixed-wing and rotorcraft segments and the small number of projected new military programs.

Overall, the U.S. aircraft industry is benefiting from the pervasive advantages of digital tools and processes, dual use linkage between commercial and military products, confidence in, and demand for U.S. products, and increased privatization within Europe. In the U.S. and Europe, exciting technological advancements across the industry are resulting in improved design and manufacturing processes spurred by the digital revolution, which hold out the prospect of lower procurement costs for aircraft and engines. Technology is also yielding improved engine durability, aircraft system reliability, and fuel consumption specifics, resulting in lower operating and maintenance costs for military and commercial customers.

While the use of subsidies continues to be discussed, both sides of the Atlantic feel that they are in full compliance with World Trade Organization (WTO) rules. While controversial, our assessment is that subsidies have little impact on the overall market.

This report will discuss the commercial transport, military fixed-wing, military and commercial rotorcraft, and jet engine sectors of the aircraft industry and address the broad industry trends and issues.

COMMERCIAL TRANSPORT AIRCRAFT

The only two competitors in the large commercial aircraft market, Europe's AIC and the Boeing Company delivered nearly 800 aircraft in 2000.[3] Recently the Airbus consortium was reorganized into a single corporate entity now known as the "Airbus Integrated Company," of which the European Aeronautics and Space Company (EADS) owns 80 % and British Aerospace and Electrical Systems (BAE Systems) owns the remaining 20%. EADS itself is a product of consolidation having finalized its new structure in July 2000. The new EADS company combined France's Aerospatiale Matra SA, Germany's DaimlerChrysler AerospaceAG, and the Spanish Government-owned CASA. EADS is now Europe's largest aerospace company and the third largest in the world, in annual sales, behind Boeing and Lockheed-Martin. Under its new organization, EADS has a more conventional corporate structure with greater financial transparency and shareholder obligations. While it is too soon to know the full impact, the EADS and AIC consolidations appears to be a positive change in the industry and in the long run should benefit the consumer. The new structure which emphasizes cost cutting, reducing duplication and increasing profitability, will likely boost overall efficiency and make Airbus an even stronger competitor.

Boeing's commercial aircraft focus has been their effort to transform from a commercial aircraft producer to a diversified, global aerospace industry leader. The transformation includes a new corporate architecture, establishing a communications business, and moving the corporate headquarters away from their primary operations center in Seattle. This new corporate structure elevates the three largest business unit executives to Chief Executive Officer status, which Boeing believes will allow a leaner headquarters to concentrate on new business opportunities and shareholder value.

We believe the changes in Boeing and Airbus will make both companies stronger. The changes will also increase competition that will result in greater innovation within the industry and ultimately better customer value. The competition for market share will be intense, but if the projections for commercial aircraft prove reasonably accurate, there will be ample work for both companies.

Demand For Commercial Transport Aircraft. Historically, long-term air travel rates have grown faster than the world's Gross Domestic Product (GDP). However, short-term air travel rates are cyclical. The demand for new airliners follows the air travel rates. Consequently, the demand is also cyclical, but has shown an upward trend over the long term. The increase in orders during the upswing causes backlogs due to under-capacity. An airline can wait as long as four years for a new aircraft. To maintain steady profits, the commercial industry is moving toward diversification, to include an increased share of the military and post-production Maintenance, Rework and Overhaul (MRO). The industry is currently on the downside of the latest short-term demand cycle. Boeing and Airbus together, delivered 13% fewer aircraft in 2000 than in 1999.[4] However, both companies project growth of the air travel market over the next twenty years to be just under 5% annually. With that growth rate and the requirement to replace aging aircraft, the world's fleet of commercial passenger and cargo aircraft will more than double in the next twenty years. The combination of increased air travel, growth in air-freight and replacement of older aircraft will fuel the $1.3T commercial transport market in the next twenty years.[5]

Meeting Market Demand. Both Airbus and Boeing are working to capture a larger share of the market. The different strategies they are pursuing is one of the most interesting events taking place in the industry today.

Boeing is basing their strategy on the belief that airline customers, especially business travelers, want to travel faster from point-to-point, and will pay accordingly for that service. During the period following deregulation, the average number of seats per airplane-mile in all but the transpacific market went down. Even with the Pacific included, world long-haul flows are using airplanes ten seats smaller in 1999 than they used in 1985.[6] The passenger's demand for non-stop flights, at the time they wanted to travel, drove airline strategies. Those strategies led to an increase in flight frequency and a decline in the aircraft size.[7] Boeing is structuring their aircraft products to meet the passenger's demand for more point-to-point travel. The recent announcement of their plan to suspend efforts to develop the 747X and proceed with development of the Mach 0.95 Sonic Cruiser aircraft reflects this philosophy. Boeing is still reviewing the business case for the Sonic Cruiser, but if they proceed with the project, it will be their largest development effort since building the 747 in the 1960's.[8]

Airbus's strategy is strikingly different and is based on the philosophy of using very large, high seat-capacity aircraft to overcome the constraints of a limited air traffic control system and restricted airport infrastructure. Airbus forecasts that annual airport departures will increase 3.8% per year through 2009 and after that, limited infrastructure capacity will constrain further growth to 2.7% per year.[9] In order to keep up with the demand for air travel, Airbus believes the airlines will have to offer as many as 19% more seats per aircraft in some markets.[10] To compete in the market as seat requirements rise, Airbus launched the A380 aircraft program. The A380 will be able to carry up to 656 passengers. Airbus currently has over 60 confirmed orders for the A380 and expects to have over 100 before the close of 2001, with first delivery in 2006. The A380 will be the first direct competitor to the Boeing 747, a monopoly Boeing has enjoyed since 1969. If Airbus is right, sale of Boeing's lucrative 747s and 777s will face stiff competition. In addition Airbus hopes that airlines purchasing the A380 will fill out their fleet with a family of Airbus aircraft.

There is a market for both strategies. Boeing may lose market share to the A380; however, if they continue to innovate and remain competitive, this should not adversely affect the overall standing of the company.

Outlook. With all the projections pointing towards a growing demand for commercial aircraft, we believe the future appears bright for Airbus and Boeing. Both companies enjoy a healthy backlog of orders; it will take both aircraft manufacturers to meet the future demands of the market.

In developing their product line of commercial transports, Airbus has proven to be innovative and a technical leader. However, they still face significant challenges integrating different cultures, business practices, and financial systems within their new organization. With the addition of the A380 to the Airbus family of aircraft, they will be able to compete with Boeing in all areas of the market, with exception of the new sector, which Boeing will create if they proceed with the Sonic Cruiser. The validity of Boeing's strategy for the Sonic Cruiser and their ability to maintain profitability in the

face of intense head to head competition from Airbus in every other market sector will be critical to the future of the U.S. commercial aircraft industry.

We believe the Airbus/Boeing competition is healthy because it is stimulating innovation in airframes, engines, production tooling and manufacturing processes. The payoff is a better product at a better price for the airlines.

FIXED-WING MILITARY AIRCRAFT

The military fixed-wing sector of the aircraft industry consists of strike, fighter, bomber, air mobility, special mission, and trainer aircraft designed, built or modified for military-unique mission requirements. Because of significant industrial consolidation since conclusion of the cold war, there are now only three U.S. companies performing substantial work involving design and manufacture of military fixed-wing aircraft: Boeing and Lockheed-Martin as prime contractors and Northrop-Grumman as a principal subcontractor and manufacturer of major aircraft assemblies.

Current Condition. The global market demand for U.S. military fixed-wing aircraft was in steady decline throughout the 1990s, and has only recently begun to improve. Since older aircraft have experienced a very low rate of replacement during this period, the U.S. is now faced with a substantial number of aircraft reaching the end of their scheduled service lives. This raises the potential for a period of significant aircraft procurement growth. The huge price tag to replace aging aircraft has forced the U.S. government to reassess the National Security Strategy and the optimal mix of military aircraft. Because of this review, the Administration could very well curtail or cancel planned procurements of the USAF F-22, the USN F-18 E/F, and/or the Joint Strike Fighter (JSF). The decision could have a significant impact on the U.S. aircraft industrial base, and future profitability and viability of some military aircraft and engine companies and their suppliers.

The Boeing Military Aircraft and Missile Division, largely a legacy of McDonnell-Douglas, is currently producing F/A-18s and T-45s for the Navy, remanufacturing AV-8Bs for the Marine Corps, and building F-15s and C-17s for the Air Force. However, of those programs, only the F/A-18E/F and C-17 promise sustained short- and mid-term business. The F/A-18E/F and C-17 are currently in rate production under multi-year contracts, but the F-15s are being produced at a minimal production rate. All that keeps the F-15 production line from closing is potential foreign sales; furthermore, as long as the line remains open additional F-15 procurements remains a possibility. Congress has approved procurement of 222 F/A-18s over the next 5 years, with follow-on acquisitions scheduled to increase that total to 548 aircraft by 2010. AV-8B Harrier remanufacture is ongoing with no viable long-term prospects because the JSF is its planned replacement. Boeing's mid- to long-term business opportunities in the high performance aircraft market are still uncertain, especially with a "winner-takes-all" JSF competition.

Lockheed-Martin's Aeronautics Division also faces a number of challenges. Lockheed's Fort Worth plant, a legacy of General Dynamics, produces the F-16--one of the world's most successful fighters. However, F-16 production is winding down. Foreign sales, such as the recent United Arab Emirates (UAE) purchase of 80 F-16s and congressionally mandated sales to the USAF keep the production line open. The UAE

purchase is an advanced version of the F-16 and is not planned for USAF use. However, as long as this aircraft is in production it remains a USAF and international alternative to the JSF. The F-22, being produced by Lockheed in Georgia and by Boeing in Washington, remains a congressional interest item because of high cost and uncertain future threats. There is much debate over the defense strategy and whether the U.S. can afford three new tactical aircraft programs (F-22, JSF, and F-18 E/F) simultaneously. Increasing congressional scrutiny, coupled with the Secretary of Defense review and Congressionally mandated Quadrennial Defense Review, has delayed the F-22 rate production decision. If the F-22 proceeds with production as expected, a multi-year contract would provide a needed financial boost to Lockheed-Martin. Lockheed-Martin's mid- to long-term business opportunities in the high performance aircraft market are also uncertain; but it is reasonably well positioned to capitalize on future business opportunities.

The transport aircraft market is also important to both Lockheed-Martin and Boeing. Recent contingencies have underscored the need for flexible airlift capable of inter- and intra-theater airlift missions. The USAF multi-year C-17 procurement contract is yielding a favorable price for the government and greater stability for Boeing. In addition, there is a potential overseas market for the C-17 as well as a proposed civil version; either would help reduce unit cost. Lockheed's C-130J is the latest model in a long line of C-130 aircraft. However, without a specific USAF requirement, production is proceeding at a very low rate supporting weak foreign and domestic sales. Lockheed-Martin developed the C-130J as a private venture and is working hard to make it successful. Lockheed's large capital investment to develop the C-130J has contributed to its lackluster financial condition. Based on Lockheed-Martin's C-130J example, it is unlikely that another U.S. company will undertake development of a new aircraft for military applications on their own funding.

Lockheed's giant C-5 continues to be an important element of the U.S. airlift capacity, specifically for oversize cargo. While not yet decided, the USAF is considering a multi-billion dollar C-5 modernization program. If this goes forward, it would provide needed work to Lockheed-Martin. The aging airlift fleet continues to demand attention and provides potential business opportunities for both companies.

In Europe, EADS has unveiled plans for a new large military transport aircraft, dubbed the A400M. This aircraft is intended to satisfy European airlift requirements, filling a market niche between the C-130J and C-17. A combination of C-17s and C-130Js could satisfy the European airlift requirements without the large development cost of a new aircraft; however, they feel the A400M is better suited to their needs. Therefore, the European preference for an independent solution is moving forward, reducing the potential market abroad for the C-17 and C-130J. European nations are committed to developing, producing and procuring indigenous military aircraft and engines. Formation of EADS is a result of European aerospace consolidation in response to continued pressure on European defense ministries to obtain better domestic value for their money. Europe's consolidated and streamlined aerospace industry is working hard to increase its share of the aircraft export market. This is especially true in emerging markets, but much of the increase will come at the expense of U.S. exports which, according to the Congressional Research Service stands at 39% of a $30B market; other large exporters include Russia (16%), Germany (13%) and China (6%).[11]

There are a large number of special mission and multipurpose aircraft reaching the end of their life expectancies in the U.S. and Europe. In the U.S. these include the KC-135, KC-10, various 707 special mission derivatives, as well as the P-3, EA-6B and E-2C. All of these aircraft require replacement with new aircraft or a new military strategy that does not depend on their unique capabilities. Satisfying these requirements in the face of fiscal realities is a challenge calling for joint and collaborative solutions. Boeing and Airbus are both developing programs to use in-production aircraft to meet these requirements. The Navy is currently exploring a concept for a collaborative Multi-Mission Maritime Aircraft. Considering the many countries currently flying P-3s, this could be a lucrative undertaking. Replacement of aerial tankers is another opportunity. Developing common airframes and systems suitable to all military services could reduce acquisition costs through economy of scale, expedite modernization programs, decrease operating costs, and provide mutual logistic support opportunities--if political will supports such an initiative. These new opportunities, and others associated with replacing the aging special mission and multipurpose aircraft, could be a boost to the military fixed-wing market in the future for both U.S. and European industries.

Challenges. The military segment of the aircraft industry faces many challenges due largely to fiscal constraints and shifting priorities. Administration decisions on the future of strike, attack, and bomber aircraft modernization and industry's actions to reduce excess capacity will shape the future of the industry.

The JSF source selection is the most significant event taking place today in the area of manned military aircraft. The result of this selection will determine the future shape of the military, attack aircraft industrial base, and possibly which company remains in the business as a prime contractor. The JSF program is crucial to both Lockheed-Martin and Boeing because it calls for production of nearly 3,000 short-takeoff-and-vertical-landing (STOVL), carrier-suitable (CV), and conventional-takeoff-and-landing (CTOL) aircraft for the United States and United Kingdom. Additional foreign sales could double that number, making JSF as currently planned the largest aircraft procurement in history. Accordingly, both corporations have adopted a "must win" competitive strategy. The government's acquisition strategy for JSF, with multilateral participation during development and cost as an independent variable, represents a major shift in aircraft acquisition. The vigorous competition holds the promise of reducing total aircraft procurement and ownership costs, while simultaneously enhancing weapon system performance and quality. Costs of the different JSF variants are expected to be far below traditional costs for similar aircraft. While the robust winner-take-all strategy appears to be paying big dividends in maintaining costs and product value, there may be a price to pay with the U.S. industrial base. The down-select could result in departure of one of the two remaining prime contractors from the military fighter/attack aircraft business.

The aircraft industry military fixed-wing sector is a major contributor to U.S. total aerospace exports, $62B in 1999.[12] In addition, sales to international customers reduce weapon system costs for the military services and help maintain production lines needed for spare parts and skills to repair aircraft. Further, foreign sales enhance military-to-military contacts and interoperability with our allies. Despite these benefits, European competition for a greater share of the international military aircraft market is becoming

increasingly fierce and the trend for European governments to buy European produced aircraft is increasing. JSF is an exception to this trend. The Teal Group, an independent analysis company, concludes that the death of JSF would have dire consequences for U.S. industry and America's status as a superpower.[13] It is possible that without JSF, the world fighter aircraft market may belong to the Europeans who have the modern Euro-Fighter 2000 (Typhoon), Gripen, and Rafale available today.

Outlook. Tight defense budgets, coupled with the imminent results of President Bush's "top to bottom" review of Department of Defense (DoD) programs, will likely result in dramatic changes to the military fixed-wing aircraft industry. In Europe, similar pressures have led to industry consolidation and collaborative European programs such as the A400M. JSF is leading the way with six NATO allies[14] and their industries currently participating in the program. More significantly, their respective industries have formed alliances with the JSF prime contractors, setting the stage for greater transatlantic collaboration and consolidation. European industry is clearly demonstrating world-class capabilities on JSF. Thus, with or without JSF, future military aircraft projects are likely to involve multinational industrial consortiums. The trends in Europe reflect the potential for greater polarization between the U.S. and European governments, and among industries and corporations. In the face of constrained defense resources on both sides of the Atlantic, and the increasing importance of military interoperability, complementary solutions among governments, industries, and corporations become increasingly more important.

MILITARY AND CIVIL ROTORCRAFT

The rotorcraft sector of the industry includes helicopters and tiltrotor aircraft capable of performing vertical takeoffs and landings (VTOL). These aircraft provide unique capabilities and performance characteristics that cannot be met by other types of aircraft. Rotorcraft comprise approximately 9% of the global aircraft industry's value. The sector consists of five major global competitors, three U.S. and two European, who are projected to collectively account for over 92% of the market's value over the next ten years.[15] The three major U.S. competitors are Bell Helicopter (Textron), Boeing Aircraft, and Sikorsky Aircraft (United Technology). In Europe, another step in the consolidation of the rotorcraft industry was taken in the past year when Italy's Finmeccanica and Britain's GKN united their respective Agusta and Westland helicopter divisions to form a new company known as AgustaWestland. Although the new company has established a joint management structure, each manufacturer continues to operate individual production, procurement, and engineering activities. The second European competitor is Eurocopter, a joint venture formed by France and Germany. Other companies that produce rotorcraft are relatively insignificant competitors in this sector of the global market.

Current Condition. The rotorcraft industry is in a period of transition marked by uncertain demand, a shifting regulatory environment, and overcapacity. Numerous crucial issues and procurement decisions remain unresolved, the outcomes of which will influence the sector over the next decade. The military rotorcraft market dominates this

sector, accounting for approximately 80% of production value.[16] As in the fixed-wing sector, military rotorcraft sales declined during the 1990's with repercussions felt throughout the industry. During this period, the civil rotorcraft market displayed modest but stable growth, mostly due to the robust economy. However, the growth in civil helicopter sales had little overall impact, since the civil sector makes up only 20% of the market's value.

In 2000 the rotorcraft market experienced an upswing as manufacturers delivered 1275 aircraft valued at $5.2B, a 31% increase over 1999 sales of $3.2B[17]. Rotorcraft market forecasts for the upcoming ten years vary, but most point to modest growth in both the military and civil sectors. Military sales will continue to dominate the market as both the U.S. and Europe begin to re-capitalize their aging helicopter fleets. Due to the large capital cost of rotorcraft, and their relatively high ownership and operating costs, commercial demand is especially sensitive to prevailing economic conditions, and overall growth is expected to be modest.

Challenges. The excess production capacity of the global rotorcraft industry is a major issue that must be addressed in the coming decade. Industry overcapacity, estimated in the range of 30% to 40%, contributes to production inefficiencies and increases costs.[18] If competitiveness and profitability are to be maintained, the industry must reexamine the underlying basis of the market and continue to move towards structures that efficiently support demand. The global rotorcraft industry has been slow to consolidate. It is now generally recognized, particularly in Europe, that consolidation of defense and commercial rotorcraft sectors is necessary to increase profitability through the reduction of operating costs and elimination of excess capacity. The U.S. rotorcraft industry's failure to consolidate appears to have allowed European manufacturers to gain competitive advantage. In the near term it is likely that the industry will continue to pursue consolidation through alliances, joint ventures and mergers, as manufacturers seek to achieve economies of scale, gain access to foreign markets, and retain market share. However, nationalistic tendencies, industrial base pressures, and antitrust concerns will continue to influence consolidation, and government regulations and restrictive policies could hamper further rationalization within the industry.

The greatest opportunities for consolidation seem to rest in areas in which manufacturers have little market overlap, allowing each to concentrate on its core competencies. It may be advantageous for the U.S. government to reconsider previous antitrust decisions, and to allow domestic and transatlantic consolidation to move forward. Consolidation is an effective method for companies to divest their excess infrastructure and to provide cost savings and price stability to customers. If properly managed, consolidation will allow the U.S. government to realize cost-savings in future procurement, while also maintaining a competitive sourcing environment and stable industrial base.

The focus of the U.S. military in the past decade has been on improving readiness at the expense of modernization and replacement of older rotorcraft. Procurement funding decisions have tended to concentrate on remanufacturing programs for aging airframes. During this period, European governments moved ahead with production of newly designed helicopters incorporating up-to-date technology, leading to significant decreases in rotorcraft operation and support costs. This approach has yielded a

competitive advantage for European helicopters on the world market. For example, the NH-90 requires only 2.5 maintenance man-hours per flying hour[19] in contrast to the 20 plus man-hours required to maintain aging U.S. aircraft of similar size and capability.

New production military programs in the U.S. consist of the Bell-Boeing MV/CV-22 tiltrotor and the Boeing-Sikorsky RAH-66 scout helicopter, neither of which have been approved for full-rate production. Current major U.S. military remanufacturing programs include Bell's AH-1Z and UH-1Y, Sikorsky's CH-60 and SH-60, and Boeing's AH-64D and CH-47F. In Europe, Eurocopter is in production with the NH-90 transport and Tiger attack helicopters, and AgustaWestland is manufacturing the EH-101 transport and the A-129 attack helicopter.

Outlook. The rotorcraft market is expected to experience moderate growth in 2001. Market predictions for the period from 2001 through 2005 for combined civil and military rotorcraft production total of over 4,600 units valued at $36B in 2001 dollars.[20] The ten-year forecast, 2001 through 2010, includes approximately 9,500 military and civil rotorcraft valued at $79B.[21] In an effort to increase civil helicopter sales, manufacturers have pursued the concept of helicopter fractional ownership. In theory, fractional ownership will make corporate rotorcraft more affordable to businesses, thereby increasing sales. Real-world experience in this area has tended to fall short of expectations. Due to the limited range of helicopters and the regional orientation of their operators, stand-alone helicopter fractional ownership programs have yet to develop a robust market for their services. Future success in this emerging market will most likely rest in manufacturers teaming with well-established business jet fractional ownership programs to provide clients with door-to-door service.

The greatest competitive advantage the U.S. rotorcraft industry will enjoy in the coming decade rests on tiltrotor technology. Despite uncertainties surrounding the V-22 program, the U.S. Marine Corps remains fully committed to fielding the aircraft. Indications are that the V-22 is likely to continue to move towards full rate production. If executed as presently envisioned, the program will be worth $9.8B in production deliveries between 2000 and 2009. This represents about 13% of the total dollar value of rotorcraft deliveries planned over this period.[22] Bell estimates that combined military and civil tiltrotor aircraft will account for over 50% of its sales during the next ten years.[23] Support and procurement of tiltrotor technology by the U.S. government is vital for the domestic rotorcraft industry to maintain its competitive advantage in this promising new market.

The Bell/Agusta joint venture to develop and produce an 8-10 seat civil tiltrotor, the BA-609 is proceeding on course, with first commercial deliveries scheduled to commence in 2003. Over 80 BA-609 orders from customers in 18 countries have already been received. An ongoing issue is the need to develop and implement operating and air traffic control rules for civil tiltrotor aircraft. This is proving difficult due to the impediments of the FAA bureaucracy, and could limit the effectiveness and utilization of the tiltrotor's unique capabilities, threatening the commercial viability of this emerging market. If FAA certification of the BA-609 is delayed, and operational rules governing its use are not implemented in a timely fashion, aircraft will be grounded upon delivery and future sales will be in jeopardy.

Despite the problems encountered during the development of the V-22, its tiltrotor technology has been shown to provide significant military utility. As a result, the U.S. military is showing increased interest in a heavy-lift, four-engine "Quad" tiltrotor concept. In July 2000 the Defense Advanced Research Projects Agency awarded Bell a contract to study feasibility of a "Quad" tiltrotor design with capacity similar to the C-130 and high propulsion commonality with the V-22. Bell hopes to construct a prototype aircraft in 2002 and believes that a production aircraft could be fielded as early as 2010[24]. Considering fiscal constraints and the history of the V-22, we believe this prediction is overly optimistic.

The European Union's Fifth Framework Program has established tiltrotor technology as a research and technological development priority. Nevertheless, the response of European manufacturers and governments to counter the U.S. lead has not been comprehensive or well coordinated. European tiltrotor proposals tend to fall into the 12-20 seat range to avoid direct competition with the BA-609. The lack of a European military requirement for a tiltrotor aircraft, and continued military investment in conventional helicopters serves to dissuade the development of costly tiltrotor technology to challenge the U.S. lead.

JET AIRCRAFT GAS TURBINE ENGINES

In the production of jet aircraft engines, GE leads the industry, followed by P & W, SNECMA of France and Rolls-Royce of the United Kingdom.[25] Projected demand for aircraft engines over the next two decades follows the demand for commercial and military aircraft, and rotorcraft discussed in earlier sections. Global reductions in defense expenditures and force structure have kept the military engine market relatively flat. However, if all current military aircraft procurement programs go forward jet engine sales will increase substantially. With foreign sales and spares, the JSF requirement alone could reach 7000 engines.[26] Low profit margins on engine sales have prompted engine manufacturers to implement cost and risk reduction initiatives. New engines are derived from existing designs and partnerships are formed to share costs and open international markets. Engine companies are selling engines at very low profit margins and hoping to recover costs through long-term parts and repair work.

Current Condition. The commercial and military engine segments are currently healthy but that could rapidly change. Strengths include the positive influences of a stable market, for instance, multi-year procurement of the F/A-18E/F and the C-17. The benefits of digital tools, innovative processes, and linkage between commercial and military products are positive indicators of a bright future in engine manufacture. Negative influences include the small number of new programs, short-term corporate views toward capital investment and R&D spending, the threat of cancellation of major programs due to fiscal constraints, offsets and subsidies, and the declining ability to attract quality aerospace professionals.

There also is an increasing trend towards mergers and collaboration between competing engine companies through establishment of limited partnerships. These partnering arrangements enable companies to share the costs and risks of new engine development, gain access to international markets, share expertise and further narrow the

competitive field for future engine sales to be used on a particular model or family of aircraft. For example, Pratt and Whitney and General Electric agreed to cooperate on the Army's Common Engine Program (AH-64 and UH-60/MH-60) as well as the GP7100/7200 engine for the Airbus A380.

Interagency, joint government and industry, and industry R&D programs are fueling engine improvements, which contribute favorably to U.S. engine competitiveness. Several factors are stimulating these improvements. Foremost is the airline requirement for safe and durable engines, which provide low operating costs, improved fuel consumption specifics, and high reliability. The second major factor is the stringent environmental requirements for quiet, low pollution commercial engines. The military services are also demanding unprecedented engine reliability, maintainability and durability, all of this within very tight cost constraints. The F-22 and JSF also require engines that produce very high thrust to weight to meet demanding performance requirements.

Government-funded R&D applicable to specific aircraft programs such as the F-22 (P&W F-119) and JSF (P&W F-119 and GE F-120) are producing near-term improvements in all of the above areas. Reduced availability of government funding has prompted a shift in research scope and priorities. Joint DoD and National Aeronautics and Space Administration (NASA) sponsored research is performed with a focus towards those items that are of mutual military and commercial interest. Examples include the joint Government and Industry Integrated High Performance Turbine Engine Technology Program (IHPTET), the Ultra Efficient Engine Technology Program and the fundamental research NASA is sponsoring under their Propulsion and Power Programs. These approaches are yielding steady improvements in performance, durability, efficiency, emissions, noise reduction, reliability, and weight and cost reduction applicable to military and commercial engines.

Engine companies are directing their R&D investment towards obtaining a competitive advantage. Because of the highly competitive nature of the engine business, industry closely guards their R&D work. However, company R&D resources are required for the multi-billion dollar costs of developing new engines, limiting the basic research they are able to perform. In addition, shareholders seeking near term benefits shun investment in technology development. This, and low profitability on sales, is constraining the funds available to the engine industry for development of new technologies and has prompted industry to shift emphasis to incremental design improvements, rather than leap ahead, higher risk, more expensive technological improvements.

Challenges. The greatest challenge facing the U.S. aircraft engine industry is the need to remain profitable in the face of intense competition for commercial sales and the uncertain market for military engines. If actions to maintain profitability are not successful, further consolidation of the industry likely will occur.

Outlook. The intensely competitive engine market will continue to deliver high quality products. Teaming to mitigate risk and open markets will dominate new-product development. The multi-billion dollar cost for development of a new engine that does not capture a large market can jeopardize a corporation's financial health and viability.

Partnering, within and across borders, is blurring traditional company and national boundaries, thereby complicating defense industrial base and mobilization strategies. International collaboration itself is subject to the complications of statutory and regulatory constraints on exports and technology transfer, which are hindering the entire industry. Nevertheless, engine companies will likely continue and even accelerate establishment of unique coalitions and partnerships within the U.S. and across the oceans to develop and produce new engines, primarily for commercial applications, but also for military applications. This may also lead to further consolidation of the engine industry. Rolls-Royce Chairman, Sir Ralph Robbins announced in March that Rolls is actively seeking alliances with other engine makers to expand its worldwide presence. However, it is most likely that mergers will primarily be between the major companies and the smaller engine companies (MTU, ITP, Fiat, Volvo and IHI), although one or more mergers among the giants are possible. Real constraints on defense budgets will limit U.S. military aircraft procurement impacting directly on sales of military engines. If JSF is cancelled, the U.S. engine industry will be weakened. It is even possible that such an event would contribute to the exit of one of the major U.S. engine companies through a buy out or merger.

INDUSTRY TRENDS

Maintenance, Rework and Overhaul (MRO). Companies within all four aircraft industry sectors are moving aggressively to increase their share of aftermarket services as a path to increased profitability and a means of smoothing the cyclic nature of aircraft and engine sales. Boeing projects that the MRO market for aviation support services will exceed $2.5T in the next twenty years[27]. Airbus and the engine companies are approaching the market in a similar way. They believe aircraft sales will improve by offering customers an integrated array of products and services to support the entire airline operation.[28] Thus they are offering a full range of MRO services to their customers. These services include training, engineering and technical support, materials/spares, flight operations, and even business management.[29] Rolls-Royce is selling long term "Power by the Hour" fleet service agreements at a set cost, and Rolls-Royce guarantees engine performance and maintenance for a fixed hourly fee based on flying hours. In some cases, commercial aircraft, rotorcraft and engine manufacturers are selling their products at, or even below costs when they tie sales to a profitable long-term support agreement.

Diversification and Consolidation. Pressures of competition, market instability and pressure to "buy domestic products" are influencing changes in the aircraft industry to enhance profitability and stability. All sectors of the aircraft industry are increasingly turning to foreign sales, non-aircraft industry activities, and post-production support to bolster revenue. In the military sector, the post cold war downturn burdened the industry with considerable overcapacity and prompted significant consolidation, which we believe is not yet complete. Future consolidation in the engine and rotorcraft sectors is likely. If government resistance can be overcome, more transatlantic mergers are possible.

Electronic Processes and Tools. A pervasive trend throughout the aircraft industry is the effort to reduce costs and achieve continuous process improvement aided by lean manufacturing and the use of electronic digital tools and processes for design, manufacture, management and customer support. Advancements in the world of digital design, manufacturing, electronic commerce and business-to-business electronic transactions have revolutionized the industry creating cost savings, improving the quality of products and the speed of bringing products to market. However, substantial issues remain concerning information security and protection of proprietary data. This is seen as a significant vulnerability.

INDUSTRY ISSUES

Retention of Quality Aircraft Industry Professionals. The foremost issue facing the aircraft industry is the ability to attract and retain quality people. Skilled labor, engineers, computer and information technology professionals, managers, technicians, and mechanics are being lost. Competition from other industries, aging of the work force, industry instability and R&D spending reductions influence this trend. The resulting loss of engineers, people with software and computer skills, and experienced technicians is a major threat to the industry's future health. Retirement of older personnel, coupled with an inadequate labor pool of skilled younger workers will further exacerbate the problem. If this trend is not reversed, the aircraft industry will suffer. Bright college students, observing the high demand and salaries for information technology professionals and the decline of long-term technologically challenging prospects for the aircraft industry, are electing to study computer science and other more attractive disciplines over aerospace.

Research and Development. U.S. leadership in the aircraft industry is also being threatened by declining R&D investment. To maintain U.S. leadership in the aircraft industry, a comprehensive, multifaceted R&D program supported by government and industry is needed. Currently, the aircraft industry is investing less than 4% of revenue in R&D.[30] This compares to an average of about 15% in commercial electronics and other technology intensive industries. To enhance the competitive advantage of the aircraft industry, R&D investment should be greatly increased and focused on industrial issues, such as reduction of noise and pollution, and innovative improvements in quality, affordability and performance of aircraft and engines. In addition to the direct benefits of R&D investment, increased R&D will help to attract, develop and retain quality engineers and scientists.

Government Export and Technology Transfer Policies and Practices. The aircraft industry is increasingly global in nature and becoming more dependent on foreign suppliers and foreign sales. However, U.S. government technology transfer and export policies have not kept pace with these changes. As a result, the U.S. aircraft industry is missing both sales opportunities and the ability to form industrial alliances with foreign companies, many of whom are best in class relative to the technologies and capabilities they bring to the design and production of aircraft. These policies and practices are a primary impediment to growth and competitiveness of the U.S. aircraft industry. This includes suppliers, many of whom lack resources needed to fight the bureaucracy.

Export of U.S. aircraft, engines, subsystems and components, as well as industrial and military collaboration, are being adversely impacted by government policy and practices. We believe policies are too restrictive and the system is slow and non-responsive to requirements. This is detrimental to the industry and the U.S. economy. Excessive caveats and long time delays for approval of Technical Assistance Agreements, Export Licenses and Manufacturing License Agreements are discouraging industrial alliances and reinforcing the European desire to procure European products and aircraft, further eroding U.S. foreign market share. Current government practices in this area require significant improvement.

Environment. The importance of environmental issues to the commercial aircraft and rotorcraft industries have been steadily increasing. Stringent environmental requirements for quiet, low pollution aircraft and helicopters have put a significant burden on the airlines, and aircraft/rotorcraft and engine manufacturers. Earlier generation engines require replacement or must be modified with hush kits to ensure continued access to acoustically restricted markets. European laws, which preclude the use of hush kits to meet their noise requirements, have been an area of contention with U.S. airlines operating older aircraft that view this as an attempt to squeeze their aircraft out of the European market and promote procurement of European aircraft. Environmental issues, especially noise, also plague helicopter operators and will be an issue for growth of the tiltrotor market. The government is investing in R&D to address noise and air pollution issues. We believe there should be an increase in this type of R&D investment. The Ultra Efficient Engine Technology Program sponsored by NASA is a positive step in this direction.[31]

Air transportation infrastructure. Airlines are currently flying close to 2 billion passengers a year and the number of passengers is projected to more than double over the next 15 years. This growth is influencing the large demand for commercial aircraft, rotorcraft and engines. However, the U.S. Air Traffic Control (ATC) system, and ATC systems in other countries, are finding it difficult to support existing air traffic requirements. Unless the shortcomings in the structure and design of ATC systems improve, air traffic limitations will constrain the growth of fixed-wing and rotorcraft passenger transport. The introduction of tiltrotor aircraft into the air traffic management system will further compound the problem. A major challenge constraining the rotorcraft industry's growth is the need for construction of heliports, helipads and vertiports. If tiltrotor technology is to be commercially successful, the infrastructure will need adequate vertiport facilities to take full advantage of the unique tiltrotor point-to-point capabilities. These issues, along with commercial fixed-wing airport limitations, are a threat to future growth of the commercial aircraft and rotorcraft sectors of the aircraft industry. We believe that expansion of airport capacity and innovative solutions to air traffic management systems to provide dependable, effective, and reliable service are essential to support the growth of the air transportation industry which underpins the aircraft industry.

GOVERNMENT GOALS AND ROLES

In the U.S., policy for shaping and enabling the aircraft industry has remained laissez faire. The changing National Military Strategy by the current administration provides opportunity to give clearer direction and guidance for the future. Unlike European competition, the U.S. government relies heavily on free market competition and limits its involvement to sustainment of research and development and defense procurement. Since the end of the cold war, both research and development and defense procurement funding has declined. In a time of economic prosperity, unstable funding coupled with declining production rates makes profitability questionable. The resulting market environment has sent the industry scrambling to develop new business strategies for the future. State and Commerce Department export control and licensing laws and regulations constrain access to the global aircraft market. For example, State Department processes require 195 days, three times the legal limit, just to determine if goods destined for sales abroad even require an export license.[32] The current lack of an enabling industrial policy jeopardizes not only future U.S. competitiveness in the global market but challenges the very sustainment of a viable U.S. aircraft industrial base.

The National Military Strategy must articulate clear goals and objectives that can be translated into requirements that enable the sustainment of the U.S. aircraft industrial base and enhance long-term global competiveness. To that end, national investment priorities must be quantified in key strategic areas. Investment in basic, long-term research and development can restore U.S. leadership in advanced technology development. Congress should take a longer, more strategic view that helps stabilize the appropriations for defense procurement. Funding decisions based on short-term political priorities will continue to undermine domestic and global competitiveness. Congress, the Departments of State, Commerce, and Defense must reformulate policies to be complementary and enabling rather than contradictory and constraining. The Department of State should quantify U.S. objectives and roles in global sales of commercial and military aircraft. Today's business environment requires policies that promote international joint ventures and transnational alliances.

Additional Topics

The Aircraft Industry, Globalization, and E-commerce - CDR Mike Steinmetz, USN

The effect of the information age, globalization, and e-commerce is pervasive throughout the domestic and international aircraft industry. From advanced collaborative aircraft design software like CATIA, to the electronic management and delivery of spares from a tiered supply system such as SAP R^3, the effect is both profound and irreversible.[33] It is difficult to find any aerospace-related activity that is not engaged in leveraging information and knowledge management via lean manufacturing, e-business, and/or working towards operations in a fully integrated digital environment (IDE).

Competition has increased due to enhanced product visibility on the Internet, but the search for profits is now linked directly to a business' ability to cut excess capacity and streamline operations to ever-greater levels of efficiency.

Many companies however, have found that working within cyberspace presents many new challenges to information assurance and information infrastructure security. In the open environment of the Global Grid and World Wide Web, large companies fight to guard proprietary information while concurrently trying to guard or restrict access to government information. Smaller suppliers, on tight timelines who vie for opportunities to manufacture parts or provide services for large corporations such as Boeing and Airbus, are now saddled with substantial requirements to implement /maintain expensive design/client server software and elaborate information security systems/security measures, which increase their costs.

Trends to watch. Until business-to-business (B2B) proprietary software and information system security systems mature into a vastly more affordable option, small business will continue to place more pressure on prime contractors to fund the cost of additional software and information assurance/security, for them. As supplier product visibility/competition increases and threats to proprietary information through exploitation of IS/IT systems continues to grow, we predict further consolidation of the pool of aerospace suppliers who choose to compete for government contracts in the e-environment. Expect the long-range trickle-down effect to be a gradual consolidation of an already shrinking, government contractor base.

Assessment. We predict that small suppliers to prime contractors in the defense industry, who possess little capital to invest in enterprise IT/IS systems, will find alternate markets or go out of business within the next 3 to 4 years.

Support of Aging Aircraft - Gregg Pelowski (Department of the Navy), John Krieger (Department of Treasury), and Colonel James Solinski (USAF) [34]

The world has changed significantly since the end of the Cold War and the demise of the Soviet Union, which was partly a result of our willingness to invest in military preparedness and high technology weapons systems. The end of the Cold War caused a cry for a "Peace Dividend." As a result, the U.S. reduced the size of the military and went on a "procurement holiday." During this period, we did not buy new systems and avoided significant upgrades to existing systems.

We are now reaping what we had sown. Weapons systems far past their originally planned product lives, increasing operations and maintenance costs, and an inability to provide critically needed spare parts. The B-52 is just one example of a weapons system where many parts are no longer made and where sub tier contractors have disappeared. DoD is entering the 21st century with the average ages of its military weapon systems and equipment exceeding 20 years.

The traditional DoD approach to the support of aging aircraft has been to provide support organically. Due to the scarcity of spare parts and difficulty in recruiting and retaining skilled mechanics, this approach is becoming increasingly problematic. DoD and the Services have contributed to the aging aircraft supportability problem by reducing support for aircraft planned for retirement, but instead have found their service lives extended.

Our research found that aircraft and engine prime manufacturers had neglected the support of aircraft, especially aging aircraft, because it was not as profitable as initial sales. However, as the result of declining numbers of prime contractors, fewer new

starts, and declining sales, this area is again drawing the attention of the prime manufacturers.

Our report concluded that there is no magic bullet for solving this problem. However, the report made the following recommendations:

- Defense Logistic Agency (DLA) should continue the approach that it has already begun on the C-130 Virtual Prime Vendor Program and other programs.
-DoD must pursue a focused modernization program to replace aging systems.
-Congress and DoD fund aircraft modernization programs and modification of existing aircraft to sustain our aircraft industrial base.
-DoD should transform how the military services approach logistics support, shifting to performance-based logistics driven by war fighter logistic performance metrics.
-DoD/DLA should expand business relationships between the military and commercial maintenance support providers, focusing on war fighting requirements.
-DoD must emphasize improved partnering between DoD consumers of logistics support and internal DoD and commercial providers of this support.
-Increased use should be made of web-based supply information networks combined with simplified methods for purchasing, invoicing and payment.
-Services must consider acquisition of Flying Hour/Power by the Hour type support for aging aircraft. Additionally, Services should consider acquisition of fleet management contracts, rather than by single aircraft type.

CONCLUSION.

The U.S. aircraft industry continues to be a hallmark of American ingenuity and a key element of national power. In the wake of downsizing and consolidation coupled with declining defense budgets, the industry is pursuing new business strategies to enhance profitability, stockholder value and secure their future. These strategies will increasingly involve transnational partnerships and selective head-to-head competitions. Despite the loss of dominance, the U.S. aircraft industry remains competitive and capable of meeting current national security requirements. In the current and projected global environment the U.S. aircraft industry will continue to face stiff competition. As overall market demand approaches its next cyclic upswing, the industry continues to react and transition to a more balanced market share among competitors. Both industry and government must continue to evolve creative strategies, policies, and enabling processes that balance our nation's goals with corporate realities. Only in a joint effort by industry and the government can the U.S. preserve and enhance this important industry and key element of our national power.

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[33] CATIA is a CAD/CAM software developed by Dassault Aviation. It is the industry standard for civil and military aircraft design software.
[34] This is a summary of a report by the ICAF Aircraft Industry Study Group funded by the Defense Logistics Agency entitled: "A Report to the Defense Logistics Agency on Aging Aircraft."